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XXV.—*On the Boring of the Mollusca into Rocks, &c.; and on the removal of portions of their Shells.* By ALBANY HANCOCK, Esq.*

[With a Plate.]

FEW subjects in connexion with malacology have caused so much discussion as the well-known excavating power possessed by many of the *Acephala*. Numerous attempts have been made to explain the manner by which these creatures work out their habitations: and this matter is indeed fraught with much interest, not merely in a philosophical point of view, but also on account of its immediate relationship to the affairs of man, as all persons connected with submarine works are too well aware. The ravages perpetrated by some of these animals, and especially by the smaller individuals of the group, the *Teredines*, are occasionally of the most fearful extent, and are carried on with a rapidity scarcely to be credited.

Of the many theories advanced to explain the nature of these operations, the one most generally received is, that the animal works with the shell in the manner of a rasp or an auger: another theory extensively believed requires a solvent; particularly when the burrows are in calcareous substances: and a third, which has received distinguished notice, was proposed by Mr. Garner in his well-known paper "On the Anatomy of the *Lamelibranchiate Conchifera*," published in the second volume of the 'Transactions of the Zoological Society;' which theory accounts for the phænomenon "by the vibratile action of the parts exciting constant currents of water against the substance, aided by its impetus when drawn in down the elongated body of the animal; and in some cases, perhaps, by the rasping of the valves."

In a short notice published in the 'Annals of Natural History,'

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vol. xv. p. 114, I advanced an opinion that the animal itself is the boring instrument, and that those portions of it which come in contact with the bottom of the excavation are furnished with a peculiar armature for the purpose. But before entering further into this view, it will be better to inquire how far any of the above theories are likely to be correct*.

In the first place, then, are the excavations effected by the mechanical action of the shell? The *Teredines* are the only species that are stated to bore in the manner of an auger, and are consequently supposed to have extensive rotatory motion. On examination, the perforations of *Teredo* are found to be nearly cylindrical, perfectly circular, and frequently very tortuous, with their inferior terminations always exactly rounded. The animal, which in *T. norvegica*, according to Mr. William Thompson (Edin. New Phil. Journ. 1835), is sometimes nearly two and a half feet in length, occupies the whole channel from end to end; and is stated by Sir Everard Home to be attached to the calcareous sheath at the siphonal extremity. This attachment is alone sufficient to prevent anything like complete rotation in a continuous direction, and indeed of any rotation at all at the commencement of the burrow; but the difficulty is much augmented when the direction of the bore is taken into account, which, as above stated, is often exceedingly tortuous, turning from side to side in the most abrupt manner, and twisting in every possible direction. It is very common to find the bore turn suddenly at right angles to its original course, and after running a short way to bend again, as suddenly, and return in a parallel direction to the commencement of the track; thus forming three sides of a parallelogram, the angles at the turns being very perfect. In such a burrow as this it appears quite evident that rotation must be excessively limited, and consequently that the valves cannot cut in the manner of a centre-bit or auger. To this fact almost every piece of wood riddled by the *Teredo* bears testimony.

Many of the borers have the anterior portion of the valves covered with spines and raised striæ, which has induced the belief that these shells are able to rasp down the substances into which they penetrate. Such an opinion, however, cannot be maintained respecting those which have the valves smooth and covered with a decided epidermis, as *Saxicava*, *Lithodomus* and *Gastrochaena*: and after a little consideration it will be apparent that the shells with spines and raised striæ are likewise inade-

* Since drawing up this communication I perceive by the third part of the 'History of British Mollusca,' that the authors of that work adopt Mr. Garner's theory, which however they modify; the rasping of the valves being considered the principal agent, and the currents produced by the animal only secondary.

quate to the task assigned to them. The bottom of the excavations of all the boring bivalves,—of the *Pholades* as well as the *Teredines*,—is regularly rounded or scooped out in a manner that could scarcely result from the rasping of shells formed like those of these genera: certainly not without extensive rotatory motion, and for reasons before-mentioned it seems pretty clear that in *Teredo* the power to rotate is very limited. In *Pholas*, too, it would appear that there is not much rotatory action, as we shall afterwards endeavour to show. Indeed, it seems quite impossible to bring what is usually considered the rasping portion of the valves of *P. crispata* into contact with the bottom of the burrow; consequently in this species they can hardly be considered as boring instruments, even supposing that the spines were capable of rasping the softer sandstones, shale, chalk, wood, and limestone. In *Xylophaga* we have a pretty good proof that the anterior portions of the valves do not come into contact with the bottom of the burrow. This genus has the habit and general appearance of *Teredo*, but is distinguished from it chiefly by two accessory valves, which are so placed as to preclude, apparently, the possibility of this taking place. And in further proof that the spines are not used for such a purpose we have but to examine them: they are frequently quite sharp and perfect, bearing neither scratch nor blemish of any kind. It may be urged, undoubtedly, that nearly all these animals penetrate only the softer substances, such as chalk and shale; but it must not be forgotten that these bodies contain siliceous particles, and that *P. striata*, and most of the *Teredines*, burrow in the hardest oak. On the coast of Northumberland *P. crispata* is not unfrequently found in shaly sandstone—a material quite capable of reducing a much harder shell than it possesses. This species also occurs in the softer limestones in the same locality and on the Durham coast, and *P. dactylus*, *P. parva* and *P. papyracea* occur in the lias, which is hard and compact. There can be no doubt, however, that the softer substances alluded to above can reduce shell. I possess specimens of *P. dactylus* which are worn quite smooth towards the back of the valves by coming into contact with the sides of the excavation, while the spines on the front remain uninjured. This frequently happens with *P. crispata* and *P. candida*, which in the north of England are generally found in shale. But the most conclusive evidence that the valves are not used as rasping instruments is, that their anterior portions are frequently covered with a fine epidermis. Montagu says that this is always so in fine specimens of *Teredo navalis*. I have recently examined more than one species of this genus, and find that the striated,—that which is usually considered the cutting portion of the shell,—is sometimes covered with a fine yellowish epidermis which can be easily removed with the point of a penknife. The *Pholades*

have also a delicate, wrinkled epidermis, which spreads over the anterior spiny portions of the valves. It is sometimes imperfect, but more or less of it may be always detected: in fine specimens it even covers the spines. All the British species have it. I have seen it very finely exhibited in specimens in Mr. Alder's cabinet; particularly on *P. crispata*, *P. dactylus* and *P. papyracea*. This epidermis is so delicate that it is liable to be removed by the washing-brush, and it is probably owing to this cause that it has been so little noticed. Some years ago Mr. Gray pointed out the existence of an epidermis on these shells. After this it may seem unnecessary to say anything more on this branch of the subject, for a stronger proof than that just noticed of the inefficiency of the spines as rasping instruments can scarcely be produced. But another fact has come under my notice, and as it relates to *P. candida*, the species which Mr. Osler describes as boring with its valves, it should not, perhaps, be passed over in silence. On the coast of Northumberland this species, old and young, is generally incrustated with a fine dark sediment, which frequently covers the whole of the shell, including the spines. On the back of the valves, towards the umbones, it is very commonly removed by rubbing against the sides of the burrow, and the shell, at this part, is often nearly worn through. It is, therefore, pretty certain that in these cases no rasping by the spines in front could have taken place.

It is also worthy of remark, that the *Pholades* commence to bore immediately after leaving the parent. I have removed from excavations the fry of *P. crispata* about one-fiftieth of an inch in length, being scarcely more than the mere nucleus, of excessive tenuity, brilliantly glossy, and as yet unprovided with spines, except two or three on each valve in a state of growth. They had nevertheless made for themselves regularly-formed excavations. How?—The advocates for the mechanical rasping of the valves will find much difficulty to explain.

The excavations at first are only one-sixtieth of an inch in diameter; but as the shell grows and sinks deeper into the substance the bore widens; and as the increase is more below than above, it is of a conical form with the apex upwards. What I wish to draw the attention to here is, that the burrow does not only deepen and increase in diameter *below*, but also that it widens *above* the shell; and that the orifice, in adult individuals, is often augmented to *one-fourth* of an inch in diameter. Were the shell the only boring instrument, this could not happen; for the channel above it incloses the siphonal tubes, and after the shell has once passed through this part of the burrow it cannot again return on account of its increased size. It is clear, therefore, that the soft fleshy wall of the siphonal tubes widens this part of the channel: and this would appear to establish the fact

that a hard shelly or spinous surface is not necessary to reduce the substances into which these animals penetrate, and is strongly in favour of the opinion that the valves are not instrumental in boring.

Many naturalists, feeling convinced that the shell of these animals is too soft to cut or rasp down the hard substances into which they excavate, and being anxious to explain the phenomenon, have had recourse to the theory of a solvent. The prevailing opinion however is, that whilst *Teredo* and *Pholas* burrow by the rasping power of their valves, *Saxicava* and its allies penetrate by the aid of an acid solvent secreted by the animal. Mr. Osler maintains this opinion in his memoir on the subject published in the 'Philosophical Transactions' for 1826, but entirely failed to detect the least trace of such an acid after the most careful investigation. I have also endeavoured to ascertain the presence of a solvent of this nature, but equally without success. After having determined, beyond a doubt, that the anterior portion of the animal is the boring instrument, as will be afterwards shown; and presuming, if an acid existed, that it would be secreted by follicles in the skin of this part, I removed it from the living animal, and placing the part so removed on litmus-paper, pressed it gently between two pieces of glass, so as to force the fluids out of it: this experiment I have frequently repeated, but never succeeded in detecting an acid. Another method was also adopted for this purpose. Several specimens of various growths were taken from burrows, and placed in a vessel of fresh sea-water with the anterior portion of the animal in contact with litmus-paper. Here they remained for upwards of a week: three or four attached themselves by their byssus to the test-paper, and continued so with the excavating portion of the animal resting upon it for several days; but the result was again negative—not the slightest stain was apparent.

Mr. Osler candidly acknowledges that if *Saxicava* were ever found to penetrate non-calcareous substances, it would be fatal to this theory. Now, several observers have stated, and Mr. Garner and Mr. Clark are amongst the number, that this species does not confine its operations to calcareous bodies. I have not been able to satisfy myself on this head; but *Clavagella*, which has the mantle closed and thickened in front as in *Saxicava*, and which cannot be supposed to bore by the action of the valves, has been found, according to Mr. Broderip, "in siliceous grit like that of the coal-measures." Few will doubt that the instrument is the same in these two genera; and if we are to believe that all the *Acephala* excavate by the same means and that a solvent is the agent, then we must allow that its powers are of the most extraordinary nature; for whilst it must be able to dissolve limestone,

shell, shale, shaly sandstone, siliceous grit and wood, it appears incapable of injuring the shell of the animal that secretes it.

It has been urged by those naturalists who advocate the existence of such an unknown solvent, that it may be applied in such a way as not to touch the calcareous covering of the animal, and that vitality may resist ordinary chemical action. It is difficult to understand how this can be; and it is quite certain that the shell of the living *Saxicava rugosa* cannot retard the penetrating power of another individual of its own species. Mr. Osler states "that when the holes communicate, it is common to meet with one animal which has attached its byssus to another, and that in such case the second is always acted on by the assailant; and also that it frequently happens under such circumstances for the one to penetrate completely through the shell of the other." And this gentleman supposes, that when an animal is thus wounded, a "firm yellow substance" which it secretes is sufficient to resist the further progress of the intruder. It seems strange that if this substance, which is of a coriaceous or horny appearance, does really retard the progress of the animal, the epidermis should not have done so in the first instance. I have seen nothing in confirmation of Mr. Osler's supposition, though I have frequently observed what he describes; but can readily understand that the infliction must cease on the destruction of the shell to which the byssus, as before stated, was attached: this will be evident when we come to consider the animal, and the mode by which I think it penetrates.

Mr. Osler further states, that "the cuticle which had necessarily been exposed to the same agent remains uninjured and overhanging the breach." This no doubt occasionally happens, but in all the cases that I have seen, the epidermis has been entirely destroyed. I cannot however conceive that this favours the solvent theory, as Mr. Osler supposes: on the contrary, it seems to prove that friction must have been used, for how could a solvent that is unable to reduce the epidermis ever reach the shell beneath it? This can only be explained by supposing that it had been torn by friction, and pushed aside so as to expose the surface of the shell.

When the burrows communicate, which they frequently do, the edges of the passage of communication are always very sharp, so much so, indeed, as to favour strongly the theory of friction; for had a solvent been used, the probability is that those edges must have been more or less rounded. It is the same when the burrows of *Teredo* run into each other, which sometimes happens. And when the shell of *Saxicava* has been completely cut through by an assailant, the plane of the section is quite flat, and forms sharp and perfect angles with the inner and outer surfaces of the

shell. The edges of small cavities cut through remain also perfectly sharp.

It is not uncommon to find at the bottom of the burrows of *Saxicava* a fine sediment, apparently arising from the scourings of the excavation. If this be carefully removed with the point of a pen and immersed in acetic acid, effervescence ensues. A similar sediment on the back of the shell of *Gastrochana* also effervesced when treated in the same way. And if a little of the same acid be applied to the anterior portion of the animal of *Saxicava*,—that portion where Mr. Osler rightly considers the excavating instrument is situated,—the same result occurs; a convincing proof that calcareous matter was adhering to it, and strongly in support of the opinion that the boring instrument is not armed with an acid solvent. These experiments seem much in favour of mechanical action.

And after all, how is a solvent to be applied with effect under water? One way suggests itself. The surface of an adhesive disc firmly attached to the part to be eroded might secrete, and at once apply the necessary fluid: but even in this case there is a difficulty; for in exact proportion to the quantity secreted, the attachment of the disc would be diminished, and the surrounding element coming in contact with the solvent, it of course must be diluted. May the solvent be of an oily nature, or of such a character as not to mingle with water? If so, how is it to act on a substance saturated with water? But with *Saxicava* the difficulty is increased, for it is not furnished with such an adhesive disc: in this respect it differs from *Pholas* and *Teredo*.

The burrows of *Saxicava* on the Northumberland and Durham coasts occasionally pass through the soft, porous parts of the magnesian limestone, which are completely saturated with water. It might, therefore, be supposed that any solvent secretion would be so diluted as to be rendered impotent. And it is common for *Lithodomus* and several other borers to bury themselves in corals, some of which, on account of their open texture, must contain large quantities of water. Mr. Fryer of Whitley possesses a specimen of coral thus excavated, which has the cells so large that the sides of the burrows resemble a section of a bundle of small crow-quills. In this case it is almost impossible to conceive how any solvent could act on the thin laminæ that divide the cells, which, of course, would be filled with water ready at every point to mingle with and to destroy the corrosive effect of any fluid secreted by the animal.

Turton entertains the opinion that the *Pholades* penetrate by the aid of phosphoric acid. He adopted this notion from having investigated the habits of *P. dactylus*, *P. parva* and *P. candida* on the Devonshire coast, where, according to his account,

they all burrow in a soft sandy material cemented by lime. But all these species are stated by Montagu to occur in wood. On the coast of Northumberland, *P. candida* and *P. crispata*, as before mentioned, burrow in shale; the latter occasionally in shaly sandstone; and Mr. Hogg has found these two species in wood at Seaton. There can be little doubt, however, that all the *Pholades* penetrate by the same means; and as *P. striata* bores into the hardest oak, it is evident that its excavating powers are equal to those of *Teredo*: and from the close alliance of the two, it is but fair to assume that the instrument is the same in both. Now, since the discovery of excessively fine sawdust in the body of *Teredo*, we cannot deny that it bores mechanically; and must therefore conclude that *Pholas* does the same, or at least, that such is probable.

Some, indeed, have doubted the nature of the impalpable sawdust found by Sir Everard Home in the interior of *Teredo*; but having had the opportunity of examining a great number of specimens, I feel perfectly satisfied of his accuracy, and also of that of Mr. Hatchett, who had this substance submitted to him, and found it unaltered by the action of the stomach or otherwise chemically changed. In many instances I have taken the reduced wood from the half-decayed and dried-up bodies of these animals: it fills nearly one-third of the worn-like portion of the creature. In a piece of deal in my possession, well filled with *Teredo*, every individual contains more or less of this microscopic sawdust, which is of a pale yellow colour of the same tint as the wood, and when moist is soft and pulpy: it readily separates in water, and exhibits a granular appearance: when dry it burns freely with a flame, chars, and emits a smell exactly like that of burnt wood. I have also taken this comminuted wood out of animals buried in mahogany: in this case the sawdust is a dark obscure red resembling the colour of the wood. Sir Everard is not inclined to believe that the animal derives any nourishment from the wood, and, indeed, its unaltered state goes far to prove that it does not. The passage of the reduced wood through the body of the animal would appear to be necessitated by the great length and tortuous direction of the bore, which we have already seen is entirely filled up by the *Teredo*. The partial attachment of the siphonal extremity to the calcareous sheath would also tend to prevent an exit in the usual way.

The theory of Mr. Garner, that the currents of water produced by the vibratile cilia of the animal are sufficient to work out the excavations, appears to be very unsatisfactory, and quite inadequate to explain the phænomena attending this interesting subject.

In the first place it must be borne in mind, that the burrows

are made with great rapidity. It is stated by Mr. Thompson, in the paper before alluded to, that *Teredo* is known "to have destroyed the keel of a vessel afloat in the short space of four or five months." And a piece of deal is said to have been riddled by it in the course of forty days*. *Saxicava* and its allies, as well as the *Pholades*, make their excavations of a pyramidal form, increasing downwards as the animal enlarges. The boring must, therefore, cease so soon as the shell has attained its full size, or the excavations would be continued with the sides parallel. From this it would appear that the burrows of these animals are the work of a very limited period—that of growth. Neither must it be forgotten, that the usual currents produced by cilia are so exceedingly feeble and limited as to require the aid of a lens to exhibit them. But Mr. Garner supposes that their velocity, and consequently that their strength, may be increased by being drawn through the elongated body of the animal. Should the currents be the ordinary siphonal currents,—and this seems to be Mr. Garner's opinion,—it is difficult to conceive how they could subserve their ordinary functions; and how the delicate tissues of the gills could escape injury, were the water hurried over their surfaces in the manner supposed.

The foot of *Pholas* is, undoubtedly, ciliated; but the external wall of the siphonal tubes, which we have seen enlarges the channel of the burrow, is not; neither is the mantle, and it, as will afterwards appear, is a very material agent in boring. The foot of the *Acephala* is usually—perhaps always—clothed with vibratile cilia; there is therefore nothing extraordinary in their presence in this case. They are probably for the purpose of cleansing the surface, and may in this way be eminently useful to the boring mollusks. Mr. Garner, however, appears to apply his theory more particularly to *Saxicava* and its allies. But the mantle of *Saxicava rugosa* is completely closed in front, and consequently there is no outlet for the currents at the very place where the greatest friction is required: further back there is a small opening for the foot and byssus; but were the currents to pass by this orifice, the byssal attachment would be destroyed and operations thereby stopped. *Gastrochæna* also has no frontal outlet, neither has *Clavagella*. There are no cilia on the anterior portion of the animal of *Saxicava*—that portion which is the excavating instrument. Towards the end of the foot, which is small and narrow, there are certainly cilia as in the other *Acephala*; but it is impossible for a moment to entertain the opinion that the currents produced by these could work out the excavations of this species.

* Penny Cyclopædia, vol. xxiv. p. 224.

Some of the Gasteropods,—*Patella*, *Hipponyx* and others, are well known to make holes in rocks and other hard substances. On the coast of Northumberland *Patella vulgata* occasionally sinks half an inch into the softer kinds of stone; and Mr. Garner asserts that it often forms holes an inch deep. Mr. John Edward Gray, in his valuable paper on the Economy of the Molluscous Animals, published in the 'Philosophical Transactions' for 1833, expresses an opinion that these holes are produced by the dissolving powers of the animal, not having observed *Patella* or the boring *Acephala* to penetrate any but calcareous substances, and those cemented by lime, wood and clay excepted. At Cullercoats, however, where there are rocks of various kinds, *Patella* does not confine its operations to such as contain lime; it sinks equally deep into shale and shaly sandstone, and even slight impressions are occasionally made into the less compact siliceous sandstones. The idea of a solvent would, therefore, appear untenable. *Patella* certainly does not bore into the compact siliceous freestones; even the very hard limestones are never deeply penetrated by it: into the softer rocks above-named it sinks deeper, and still deeper in proportion to their softness.

Mr. Garner, in following up his views, maintains the opinion that it is by the action of the ciliated branchiæ that these excavations are made. But on examining them we find that there is generally an elevated ridge corresponding to the space between the mantle and foot; in which space the gills are placed, and where, of course, the currents are strongest. Were these excavations effected by the branchial currents, there ought, certainly, to be a depression in the place of this ridge.

The holes made by *Patella* vary considerably in different materials. In hard stone not more than a mere circle, corresponding to the edge of the mantle, is produced: in soft limestone the mantle sinks to some depth, leaving the portion on which the foot rests projecting up in the centre, sometimes more than one-eighth of an inch. In the sound shales the bores are frequently almost flat; but in those that are friable, the foot, by its strong grasping powers, tears up the stone, and thereby makes a deepish cavity in the centre of the burrow: the surface of this cavity has a rough and broken appearance, and is surrounded by a smooth elevated rim sunk a little beneath the general surface of the stone: this rim is produced by the mantle*.

* The form of the shell of *Patella* is modified in consequence of this diversity of the burrows. When they are flat, the shell attains its normal growth; when the centre is elevated and the margin corresponding to the mantle depressed, the shell becomes very much raised: but it is flattened in a most extraordinary manner when the foot sinks deep into the centre of the excavation.

The under surface of the foot of *Patella* is clothed with vibratile cilia; but, as just stated, that part of the animal does not sink so deep into the rock as the mantle, except when the surface breaks up under the grasp of this powerful adhesive disc. There are no cilia on the mantle, therefore the reverse of this might be expected to take place were Mr. Garner's theory correct. The cilia on the foot are not at all peculiar to this animal: I have detected them also in *Doris*, *Limapontia*, *Purpura* and *Littorina*; and it is worthy of remark that in all these they are very much larger and more vigorous than in *Patella*, in which they are so extremely small that it requires the greatest care and high magnifying powers to make them out.

Let us now for a moment suppose that these currents are capable of reducing the substances into which these animals penetrate, and that a *Patella* attached to shale, or any other rock, is working its way into it. What are the currents effecting all the time on the surface around the shell—those currents being ten thousand times more powerful than the minute, microscopic ones produced by the animal? Must not the action of the advancing and receding tides, augmented by the rolling of the waves to and fro, triturate the surface of the rock more rapidly than the comparatively feeble, ciliary currents of the gills and foot? Were the excavating powers, therefore, limited to these currents, should not the *Patella* stand upon an eminence rather than be half-buried in a hole? This argument also applies with equal force to *Pholas*, and still more strongly to *Teredo*; for surely it can never be maintained that the triturating effect of water on the planks of a vessel, sailing at the rate, occasionally, of ten knots an hour, is less than the almost imperceptible currents produced by the *Teredo*, which will penetrate several inches into the timber during a voyage from India.

I fortunately possess three or four specimens exhibiting the bores of *Patella*, which perhaps may be considered sufficient to prove that the animal works mechanically, and in a way that currents of water could scarcely act. The first of these bores is that of a small *Patella*: it is sunk only a little way into the surface of a gigantic species of the same genus from the coast of America, and exhibits minute striæ or scratches radiating from the centre to the circumference. I have seen another specimen of this gigantic *Patella*, in the collection of Mr. Fryer, which is marked with several similar impressions, one of which is scratched in the same manner, but more distinctly. In this specimen the whole surface of the impression is covered with lines radiating from the extreme circumference to a spot near the centre. The lines or scratches are in groups, and so small as to require a powerful lens to show them. At first I thought it possible that

these lines might, in some way, be connected with the structure of the shell, though it was impossible to explain how this could be. Since then I have procured from the coast, in the neighbourhood of the Tyne, specimens of the bores of the common *Patella* in shale and limestone very distinctly marked with the same radiating striæ or scratches; thus proving satisfactorily that the radiating lines in the former instances are not structural, and that the foot and mantle of the animal possess the power of reducing those substances mechanically. But certainly not by ciliary currents, unless they be supposed capable of producing a scratched surface; and if so, how are the currents in the cases cited to pass away, meeting as they must under the centre of the foot*?

Having stated the facts, and having gone through the reasons that induce me to consider the three generally received theories insufficient to account for the operations of the stone- and wood-boring mollusks, I shall now proceed to explain my own views on the subject.

It has been already stated that I have expressed an opinion that the anterior portion of the animal is the excavating instrument. This in *Teredo* and *Pholas* is composed of the foot and the edges of the mantle, which, together, entirely fill up the frontal gape of the shell. In *Saxicava* and *Gastrochaena* it is formed wholly of the edges of the mantle, which are united and thickened. The foot and mantle of *Teredo* protrude before the valves: the former is circular and convex in front, and there is little doubt, from the resemblance it bears to the same part in *Pholas*, that it adheres to the bottom of the burrow, with which in form it precisely agrees. Sir Everard Home calls this the "proboscis," which, he says, "in the living animal had a *vermicular motion*: the extremity was covered by a cuticle not unlike the cornea of the eye." Sir Everard also remarks, "that as this proboscis has no orifice, there is reason to believe that it adheres to the wood, acting as a centre-bit, while the animal is at work with the shell." Not having seen *Teredo* alive, I cannot speak from my own knowledge to the exact form of these parts; but from the examination of specimens in spirits I have no doubt of the accuracy of this description, which proves that the foot or "proboscis" corresponds exactly in form to the bottom of the burrow. The comparison of this part to the "cornea of the eye"

* In the 'History of British Mollusca,' it is stated that in Mr. Cuming's collection there is a specimen of *Pholas* which has made its excavation in wax; a circumstance scarcely favourable to the opinion advanced by the authors of that work. Currents of water could have very little effect on a substance of this nature, and it would be very liable to clog the rasping surface of the valves so as to retard operations, if not to stay them entirely.

is most conclusive, for a better idea could not be given of the peculiar concavity of the bottom of the burrow than by an allusion to this object.

The foot of *Pholas crispata* is like that of *Teredo*: it projects in front of the valves, is very large and convex in front, agreeing also in shape with the bottom of the burrow, to which it closely and constantly adheres. The free borders of the mantle surround this organ, and together with it almost fill up the bottom of the excavation, the concavity of which so exactly corresponds to the convexity of those parts that the one might be supposed to be moulded on the other. *P. candida* and *P. parva* have the foot and anterior portion of the animal formed in the like manner, being only specifically modified; and, judging from analogy, there can be no doubt that all the individuals of this group are constructed after the same type. *P. papyracea* and *P. striata*, from being closed in front when mature, might be thought to have the animal differently formed. But we have the authority of Mr. G. B. Sowerby for asserting that *P. laminata* is the young of the one, and *P. minuta* of the other. If this be the case (and having carefully examined specimens of them all, I am inclined to the same opinion), the animal of these two species when young will undoubtedly resemble that of *P. crispata*, and the excavations must be made whilst in that state. We have already seen that the burrows of all the boring bivalves are formed during the growth of the animal. And in these two species after the burrows are completed the anterior gape of the shell is filled up, and probably the large foot greatly reduced.

Thus then we see that in *Teredo* and *Pholas* the anterior portion of the animal corresponds in form to that of the bottom of the excavation. How is this in *Saxicava rugosa*? Precisely the same. The parts however are modified.

The animal of this species, and of that of *Gastrochæna Pholadia*, are alike: they are both closely enveloped in the mantle, having only siphonal orifices, and a small perforation about one-third of the length of the shell from the anterior end for the passage of the byssus and a small slender foot, which is occasionally protruded. The mantle in front is much thickened, and forms a sort of cushion-like swelling of an elliptical form, extending some way backwards, and which at the will of the animal can be thrust out considerably in advance of the valves. The arch of the front of this cushion corresponds to the concavity of the bottom of the burrow. As before stated, this part of the animal has not the power of adhering to the substance to be eroded, but is held in contact with it by the attachment of the byssus; and, howsoever the excavation may be effected, there can be no doubt that this thickened portion of the mantle is the instrument.

Burrows frequently occur with a depression at the bottom exactly agreeing in form and size with this part of the animal, and it very commonly happens that there is an elevated point in the depressed part corresponding with the greatest accuracy to the position of the byssus. Indeed, I have seen the byssus on several occasions adhering to the projection. It seems impossible to have a more convincing proof than this, that the anterior portion of the animal is the excavating instrument.

The animals of all the species that confine their operations to calcareous bodies are most probably formed like those of *Saxicava* and *Gastrochana*. *Petricola* is stated by Mr. G. B. Sowerby to have "the borders of the mantle thickened in front with a small hole for the foot." And Professor Owen, in his paper on *Clavagella*, published in the first volume of the 'Zoological Transactions,' describes that genus as having the mantle closed and thickened in front with a small orifice for the foot. It is satisfactory to observe that this distinguished physiologist considers that the animal enlarges its habitation by this thickened portion of the mantle. I have not been able, anywhere, to find a sufficient description of the animal of *Lithodomus*; but from the remains of it in a small specimen which I found buried in an old shell, there can be little doubt that it also has the mantle closed in front.

From what has already been said respecting the holes of *Patella*, it is sufficiently evident that they also partake of the form of the animal.

The direction of the burrows of the *Acephala*, as well as their form, corroborates the opinion that the anterior part of the animal is the boring apparatus. I have examined a great number of the burrows of these animals, and find that the direction of the excavations is always inclined a little to one side: none of them are at right angles to the surface by which the animal enters. The bores of *Teredo* are so inclined at the commencement; but their course is soon altered, and is afterwards, apparently, determined at the will of the animal. The burrows of *Pholas* and *Saxicava* are generally continued their entire length in the original direction; they are, however, sometimes slightly twisted as well as inclined. This happens with *Saxicava* more frequently than with *Pholas*, and is occasioned by the animal having turned a little more to one side than usual. This obliquity of the burrow is unfavourable to the opinion of rotatory motion, and arises from the exposure of the animal towards the ventral margin of the shell. The cutting surface being therefore placed to one side, the excavations cannot be perpendicular unless complete rotation were to take place, which we shall afterwards see is unnecessary.

It now remains to be shown that the anterior parts of the ani-

mal are furnished with the means of removing the various substances into which the burrows are made. The means employed cannot be a solvent, unless we are prepared to suppose it capable of eroding argillaceous, calcareous, and siliceous bodies and also wood; and we have already seen that in the case of *Teredo* the wood is reduced to sawdust, and in no way affected by chemical action; likewise that the excavations of *Patella* occasionally exhibit a scratched surface. This latter fact would appear also to exclude the instrumentality of ciliary currents, as they can scarcely be deemed sufficient to produce such a surface. And since we have seen that *Saxicava* is unprovided with cilia on the boring instrument, few naturalists will be disposed to support the theory promulgated by Mr. Garner: all such, however, are compelled to allow that the mighty currents of the rolling tide are far less potent than the minute breathing currents of the mollusk; and that they, microscopic as they are, can in the course of a few months dig deep into hard shell and limestone,—nay, even into the hardest marble which has withstood the shock of the elements for ages. Some naturalists may still be inclined to urge that one species may work mechanically and another chemically. But is it not more philosophical to allow that animals so nearly allied as these—or at all events that all the boring *Acephala*—are more likely to effect a similar purpose by the same means, than that several should be adopted? Surely this is more consistent with the unity of the laws of nature, and that beautiful simplicity which is everywhere prevalent in her works*.

We shall now examine the anterior portions of the animal. The surface of the foot of *Teredo norvegica* when preserved in spirit is tough and coriaceous, and is entirely covered with little, irregular pimples. If a portion of it be placed in the compressor of the microscope, it is perceived to be crowded with minute, bril-

* Professor E. Forbes and Mr. Hanley, who, as before stated, advocate the mechanical action of the shell, aided by the currents produced by the animal, appear also to contemplate the probability of the assistance of an acid solvent; for they state in conclusion that “if there be any chemical action aiding, it must be due to the carbonic acid set free during the respiratory process.” The advocacy of such a multiplicity of means to effect the same purpose cannot be avoided by those who believe that the *Pholades* work out their excavations by the rasping of their valves. *Saxicava* has a smooth shell, and is unprovided with cilia on the anterior portion of the animal; therefore the assistance of an acid solvent must be resorted to in this case. But in that of *Patella*, which penetrates shale and shaly sandstone as well as calcareous bodies, such a solvent cannot be supposed to act for the same reason that would preclude its use in the *Pholades*; and therefore in *Patella* the currents produced by the animal must be imagined to operate, as the shell here is out of the question. Thus all these three means are requisite to account for the phenomenon, if the theory proposed in the ‘History of British Mollusca’ be correct.

liant points ; and on increasing the pressure, comparatively large imbedded, crystalline bodies are revealed (Pl.VIII. figs. 6 and 7). They are very numerous and of various sizes and shapes, chiefly five- and six-sided, but not by any means regularly so : they all agree in having one or more elevated points near the centre. It was these points, apparently, that were seen in the first instance shining on the surface. These bodies are highly refractive, and are for the most part pretty regularly distributed over the whole convex surface of the foot, but are occasionally congregated into masses. Similar crystalline bodies are likewise imbedded in the edges of the mantle surrounding the foot.

In *Pholas* the same appearance is presented both in the foot and in the surrounding edges of the mantle. When the anterior convex surface of the foot of *P. crispata*, for instance, is removed and examined with the aid of the compressor, it is found to be studded over with minute dark spots, each emitting a brilliant point of light from the centre. On using a higher magnifying power the whole surface is seen to be crowded with crystalline bodies, some dark-coloured, others perfectly transparent, and resembling in shape and character those of *Teredo* ; but most commonly drawn together into little bundles, and very brilliant : they are sometimes also gathered into considerable masses. These bodies in some specimens are quite colourless ; but when of a dark reddish brown, which is not uncommon, they have at first sight a glandular appearance, especially when the imbedding tissue is a little thickened about them, which frequently happens. The dark spots of a glandular aspect observed by Professor Owen in the outer dermoid layer of the mantle of *Clavagella* may probably prove to be similar crystalline bodies.

Saxicava rugosa has also the anterior portion of the animal abundantly provided with crystalline bodies like those already described (figs. 1 and 2) ; but they are for the most part larger and stouter, and are likewise frequently associated in groups. They are highly refractive, perfectly colourless and of a glassy purity ; and are imbedded in a thinnish epidermis, which is firmly attached in the living state to the thickened portion of the mantle, but is easily peeled off when the animal has been some time in spirit. The thickened portion of the mantle of *Gastrochana* is also furnished with similar crystalline bodies, but from the want of specimens I have not been able to examine them in this species so fully as is desirable.

The foot and mantle of *Patella vulgata* likewise exhibit these brilliant bodies ; but in this species they are smaller and less robust than usual. In the species which has been mentioned as boring in the large *Patella* from the coast of America, they attain, however, a high degree of development. I fortunately ob-

tained a desiccated animal of this borer adhering to the base of an excavation, and on placing the foot and edges of the mantle in the compressor, large, robust crystalline bodies (figs. 3, 4) were distinctly visible, arranged in irregular groups around the margin apparently in the mantle: similar bodies were also distributed over the foot, but without the slightest tendency to order. They are mostly five- and six-sided, are thick, and have an elevated point in the centre. When crushed between glass they are liable to fracture in a radiating manner (fig. 5), as if from the influence of the pressure on the central point.

It is difficult to say what these crystalline bodies are composed of, though there can be little doubt that they are modified epithelium scales, from which they differ chiefly in being very robust, highly refractive and brilliantly crystalline. The difference between these and ordinary epithelium scales will be at once recognized, if a little of the surface of the lower portion of the siphonal tube of *Pholas* be examined in the compressor. It appears also that, like the scales of epithelium, these bodies are constantly being shed. On testing the scourings taken from the bottom of the burrow of *Saxicava*, as before-mentioned, they were found to contain a vast number of these bodies exactly corresponding with those of the mantle; and on examining the sediment adhering to the shell of *Gastrochana*, the residuum after the action of the acid had ceased was almost entirely composed of them. The reduced wood taken out of *Teredo* also contains brilliant crystalline bodies resembling those in the foot and mantle. Whether these bodies, however, are epithelium scales or not, we see in this deciduous character the means of keeping the rubbing surface in an efficient state. With pressure these bodies frequently break into sharp angular fragments. Acetic acid has no effect on them; and in *Saxicava* strong nitric acid produces no change even after several days' immersion. If allowed to remain sufficiently long in this acid the imbedding tissue is destroyed, and the crystalline bodies, not in any respect altered, are left as a sedimentary residuum. Those of *Pholas* and *Teredo*, however, appear to be ultimately acted on by this acid, though they resist its power for several hours, and are never totally destroyed by it. They become attenuated and brittle, but retain much of their brilliancy and sharp angular appearance; and even some of them, especially in *Pholas*, are scarcely at all altered after having been subjected to the action of this powerfully corrosive acid for many days. From these facts it perhaps may be inferred, that these crystalline bodies are either entirely composed of siliceous matter, or are a combination of it with animal matter. These experiments certainly do not prove this; but when their results are taken in connexion with the crystalline appearance of

these bodies, and when we refer to the fact recently made known that the spines of the tongue of the Gasteropods are composed of silex, a high degree of probability is established in favour of this view ; and if it be correct, the phænomena attending the boring of the mollusks are very easily explained*.

The foot and mantle of *Teredo*, *Pholas* and *Patella*, and the thickened portion of the mantle of *Saxicava*, *Gastrochæna* and their allies, appear, then, to be rubbing discs of extraordinary power, crowded as they are with these siliceous bodies, which penetrating the surface give to it much the character of rasping or glass-paper. And all that now remains to be proved is the existence of muscles to give to this formidable cutting surface the necessary rubbing motion.

These muscles are amply provided : the adhesive portion of the foot, as well as the mantle, of *Teredo* and *Pholas*, and also of *Patella*, are composed of interlaced muscles. The anterior thickened part of the mantle of *Saxicava* is also made up of muscular fibres running in all directions. And Professor Owen, in his account of *Clavagella*, states that “the muscular layer after forming the siphon and its retractors is confined to the anterior part of the mantle, where it swells into a *thick convex mass of interlaced and chiefly transverse muscles.*” Surely this powerful muscular apparatus has some important function to perform :—not to secrete a solvent, but to assist by its mechanical agency in the work of excavation.

We now see the boring instrument complete in all its parts ; and a more efficient apparatus could not be devised. Supplied with this flinty armature, the soft fleshy foot of *Pholas* and *Teredo*, adhering to the substance to be reduced, and aided by the edges of the mantle, cuts with equal facility into wood, shale, chalk, and the various other bodies into which these mollusks burrow. *Patella* excavates in the same way. The mode is somewhat varied in *Gastrochæna* and *Saxicava* : they firmly attach themselves by the byssus to the rock, then bring into contact with it the armed and thickened portion of the mantle ; thus enabling the interlaced muscles of which it is composed to work with as much effect as those in the broad adhesive foot and mantle of *Pholas* and *Teredo*.

In none of these species is much rotatory motion required. In

* In the ‘History of British Mollusca’ the existence of siliceous bodies in the foot and mantle of *Pholas* and *Teredo* is denied. Perhaps the authors of that work may have overlooked them on account of their resemblance to epithelium scales. Silex, however, can scarcely be considered essentially necessary ; a much softer material on a living surface, and *perpetually being renewed*, may be supposed capable of rubbing down the various substances into which these animals burrow ; certainly so far as the *Pholades* and *Teredines* are concerned.

Pholas and *Teredo* little more than the mere contraction of the cutting surface is sufficient; each portion of the foot and mantle, which together nearly fill up the bottom of the excavation, acting immediately on the substance with which it is in contact. The same thing takes place in *Patella*, which evidently does not rotate, for the burrows are elliptical like the animal, and fit with great accuracy the marginal indentures of the shell. But the cutting disc of *Saxicava* and *Gastrochæna* being narrower than the burrows, these species must, at intervals, move a little from side to side, anchoring themselves afresh by the byssus whenever they shift their position. In all, however, the same vermicular contraction of the parts observed by Sir Everard Home in the foot or "proboscis" of *Teredo* will be required to remove the substances into which these animals bore.

Thus this perplexing subject is simplified; and judging from analogy, there can be little doubt that all the boring mollusks excavate in the same manner: none by the rasping or cutting of their valves,—none by a solvent,—none by ciliary currents*. We should therefore be inclined to doubt that any of the *Acephala* bore, which are not provided with either the broad adhesive foot or with the thickened mantle united in front. *Venerupis perforans* may be, perhaps, cited as an exception to this rule; but it is doubtful whether it ever bores. On the coast of Northumberland, where there is abundance of soft shale and a great variety of rocks, it certainly never does so: but it frequently takes up its

* The stone-boring *Annelides* will probably be found to work out their excavations in a similar manner. The *Cliona celata* of Grant would also appear to make the chambers it inhabits in the shells of bivalves and in other substances by mechanical agency. This curious production was supposed by its describer to take up its abode in excavations made by marine worms; but after carefully examining the cavities occupied by the *Cliona*, there can be no doubt that they are the work of this creature, most probably aided by its siliceous spicula, which penetrating the surface of the animal give to every portion of it the character of rasping-paper. In this case such an apparatus, at first sight, might be thought inefficacious, as the sponges are not contractile; but the *Cliona* is an exception to this general law. Dr. Grant states that it is "distinctly irritable," and describes the papillæ as being highly contractile; and it is worthy of remark, that this, the only boring species, is the only one that possesses this power. Dr. Grant also states that it adheres so closely to the smooth parietes of the cavities that it cannot be removed without tearing—a fact corroborative of the theory now advanced, but not at all favourable to that of an acid solvent or of ciliary currents. Were either of these agents employed, it is not likely that laceration would attend the removal of the animal, as no very intimate connexion could exist between it and the walls of the bore. But from the nature of the apparatus, as just described, it is evident that the creature would be held in its place by the siliceous points on its surface, and thereby removal rendered difficult.

abode in the old burrows of *Pholas* and *Saxicava*; and it is probably owing to this habit that powers have been attributed to it which it does not possess. From a similar habit, *Kellia suborbicularis* has also been stated to excavate; and it is not unlikely that several other reputed borers have no better title to be so considered.

It may still be asked;—if the armature be of this formidable nature, how is it that *Saxicava* is entirely confined to calcareous substances? Why should it not likewise burrow in softer materials, such as wood and shale? This may be answered by another question—why do *Teredo* and *Pholas striata* always bore in wood? And why is not *Saxicava* itself found in shells of other mollusks, as is frequently the case with *Lithodomus*? for certainly an acid solvent could dissolve the calcareous covering of these animals as well as hard limestone.

Some impulsive instinct is most probably the guidance in these matters, leading each species to that substance best suited, in some way or other, to the œconomy of its life. This selection, without an apparent cause, is observed everywhere in the wide field of nature: we see it in the nests of birds, which in closely allied species are frequently built of different materials; and we see it in a striking manner in the habits of the burrowing bees. The carpenter-bees (*Xylocopæ*) are well known to excavate in wood; there is a species, however, of an allied genus, the *Anthophora retusa*, which “makes its nest not only in hard dry banks but also in the crevices of walls, burrowing through the mortar, and causing much damage by loosening the bricks.” It cannot be from want of power that this species does not penetrate wood.

In *Saxicava* there is also a mechanical cause which may have something to do with the matter. It has been already stated that the rubbing instrument is held by the attachment of the byssus in contact with the substance to be excavated; and as the byssus is small, it is ill calculated to maintain its hold of soft friable rocks, such as shale, which, on the coast of Northumberland, is frequently exceedingly brittle; so much so that the *Algæ* seldom grow on it, and the *Patellæ* rarely trust themselves to its treacherous surface. *Clavagella*, however, appears to burrow in soft substances as well as in hard ones: this is easily accounted for by the fact, that the attachment of one of the valves to the side of the burrow renders the support of a byssus unnecessary; and having an extensive fulcrum, this species can therefore excavate in soft substances with as much facility as *Pholas*.

There is another phænomenon in the history of the mollusks which appears intimately connected with the subject just dis-

cussed—the power possessed by many of the Gasteropods of reducing the thickness of the columella, and of removing spines and other obstructions from it.

Mr. Gray, who has entered on this matter at some length in his paper (before quoted) in the ‘Philosophical Transactions,’ states that “this absorption of the outer part of the last whorl but one, and of the spines, is evidently effected by the edge of the mantle.” And there can be little doubt that the other instances which that gentleman mentions of the “absorption” to a greater or less extent of the septa is likewise effected by the same organ. That this view is correct we have but to refer to the *mollusca* of our own coast. The shell of *Buccinum undatum* generally exhibits a groove on the columella extending the whole length of the mouth; and if a living specimen be examined, we perceive that the edge of the mantle perfectly corresponds to this groove. *Fusus antiquus* and *Purpura lapillus* also reduce the thickness of the columella, and in both it is very easy for any one to satisfy himself that the mantle is the instrument. In *Buccinum undatum* the cutting of the columella is occasionally very deep, especially when the part has been repaired and projecting a little; in which case it is frequently under-cut, and actually overhanging the mantle.

It is difficult to say what is meant by “absorption” in these cases: nothing like the absorption of hard, inorganic matters in the higher animals can be supposed to take place here; for no vascular connexion exists between the mantle and the columella. Mr. Gray says, “Possessing this power of absorbing their own shells and the shells of other *mollusca* and calcareous rocks, it is remarkable that these animals do not exert it for the purpose of removing extraneous obstacles which may oppose their progress in the formation of their shells.” Were this indeed the fact, it would go far to support the opinion that vascular absorption, or something like it, really takes place. I possess, through the kindness of Mr. Richard Howse, two specimens which prove that these animals, however, do remove extraneous bodies from the columella. The one is a small individual of *Buccinum undatum* with a *Serpula* attached to the spire, and passing over the posterior part of the columella. This *Serpula* is completely cut through undoubtedly by the mantle, and left overhanging it for nearly a quarter of an inch. The other is a *Fusus antiquus*, which has adhering to the columella two barnacles (*Balanus communis*). These have the walls, that are next the mouth of the shell to which they are attached, cut through; proving beyond a doubt that the mantle has the power of removing extraneous matter that retards the growth of the animal. It is therefore pretty evident that these removals do not take place by vascular

absorption; and it remains to be proved whether they are effected by a mere solvent or by mechanical means.

The arguments before urged against the use of a solvent by the boring *Acephala* are to a considerable extent applicable in this case. It is impossible to conceive how it could be applied without having its powers very much impaired by the diluting effect of the surrounding element. When the mantle commences its operations on the striated surface of *Buccinum undatum*, the elevated ridges or striæ are nearly obliterated before the grooves are at all affected: the surface is therefore rapidly levelled. Were a solvent used, the reverse of this might be expected to happen, for the fluid accumulating in the depressed lines would act there more vigorously than on the elevated parts, and the consequence would be the exaggeration of the grooves. Holes and cracks cut over are not enlarged, as every one conversant with etching is aware they should be were a solvent fluid used. As before remarked, extraneous obstructions of a calcareous nature can be removed: the sandy sheath however of *Terebella lumbricalis* resists the power of the mantle. When this animal retards the growth of the mollusk, it is covered over by the inner lip, and distortion frequently arises in consequence. The sand attached by this species of *Terebella* is composed almost entirely of rather large siliceous particles; and from what we know respecting the boring of the *Acephala*, it might be inferred that the sheath of this animal could not be removed. The question is not materially affected, on either side, by this fact, though if a solvent be the agent, it must have the power, one would think, of removing in the first instance the epidermis; and if so, there does not appear any good reason why the corroding fluid should not find its way to the horny sheath that holds together the siliceous particles, and reducing it liberate the sand. The improbability of the use of an acid solvent is increased by the fact that it must be supplied by the same organ that secretes the calcareous matter forming the inner lip: certainly this may be supposed to come from the mantle further back, and the solvent from the extreme edge of it; but this does not remove the difficulty, for the one would still be liable to interfere with the other.

The action of currents is apparently out of the question in this case, as the mantle is furnished with cilia only on the surface next the animal; on that next the shell I could detect none: it is supplied, however, with crystalline bodies similar to those before described in the foot and mantle of the boring mollusks. Then, shall we not conclude that it is by their agency that the columella is reduced, and that spines and other obstructions are removed from it? Analogy would lead to this conclusion, assuming that we have arrived at a correct view respecting the boring

of the mollusks. In all the boring species I have endeavoured to show that the foot and mantle are the organs employed; and that in *Patella*, with which the analogy may be considered closest, the mantle is highly instrumental. In this species we have seen that it has the power of rubbing down shale, limestone and shell; and these substances are removed as the shell increases, apparently for the purpose of levelling the surface, and preparing it for the accommodation of the animal. The mantle of *Buccinum undatum* and of many other Gasteropods does—what? It clears away obstructions from the columella and reduces its thickness, that as the animal grows it may have sufficient room. They all, *Acephala* as well as *Gasteropoda*, rub down those hard substances only during growth, and all do so that they may find increased protection and accommodation: it is the same act in all, the same organ is employed in all; and we can scarcely doubt that in all it is furnished with the same means.

We might have gone more fully into this branch of the subject, but it appears unnecessary to do so; for if I have succeeded in substantiating my views in the former part of this communication, little need be said here; if not, all that I could now advance would be of little service, feeling strongly inclined to believe that one law regulates the whole of these phænomena.

The boring of the carnivorous Gasteropods, into bivalve and other shells, remains yet to be examined; but having already extended this paper to too great a length, this interesting portion of the subject cannot now be fully entered upon. In reference to it I shall at present make only one or two remarks before concluding.

A short time ago Mr. Richard Howse discovered *Purpura* boring on the Durham coast, and in company with that gentleman I have had several opportunities of taking this animal in the act of piercing the common *Mytilus*, which appears to be a favourite food. The holes are generally one-sixteenth of an inch in diameter, being just sufficient to admit the proboscis, which in one or two instances I have seen inserted in the bore. The tongue, which is covered with transverse rows of siliceous spines, is strap-formed and very long; it is much narrower than the bore; and the anterior spines are generally worn down, or have never been developed. The bores are for the most part circular, sometimes they are slightly oval, and frequently pass through the epidermis, which in *Mytilus* is strong and horny. When they do so the epidermis is never torn, but the edges are smooth and circular like the rest of the bore.

Putting these facts together, it is, perhaps, fair to conclude that the boring in this case is also mechanical, and that the tongue is the instrument, though it is difficult to understand

how a narrow strap-formed apparatus is to work out a circular hole. But having this powerful siliceous organ at hand, certainly capable of penetrating calcareous substances, it would be unlike the direct and simple operations of nature were another one provided. It is more likely that some mode of application is effected by which the ordinary prehensile tongue of the Gastropod is turned into a rasping or drilling instrument. The wearing down of the anterior spines appears favourable to this opinion.

EXPLANATION OF PLATE VIII.

- Fig. 1. A portion of the epidermis from the anterior cushion-like swelling of the mantle of *Saxicava rugosa*, seen in the compressor, exhibiting large crystalline bodies.
- 2. Some of the crystalline bodies from the same after having been six hours in nitric acid.
- 3. The foot and mantle of a small foreign *Patella* found dried up in an excavation, showing the arrangement of the crystalline bodies.
- 4. A group of the same crystalline bodies more highly magnified.
- 5. Four of the same bodies exhibiting radiating fractures caused by the action of the compressor.
- 6. A portion of the convex surface of the foot of *Teredo norvegica*, as seen in the compressor, exhibiting crystalline bodies.
- 7. A group of the same bodies more highly magnified.

XXVI.—*Notes on the distribution of the Fossil Conchology of the Oolitic Formations in the vicinity of Minchinhampton, Gloucestershire.* By JOHN LYCETT, Esq.*

THE following remarks have been written chiefly with a view to illustrate the contents of the author's cabinet, premising that the objects in question constitute materials fitted rather for private study than for public demonstration. The bones of gigantic Saurian reptiles, of fishes, the shells of great Cephalopods, are appreciated even by the uninstructed spectator. They speak to his senses of a creation distinct from that which he sees around him, and he is prepared to hear of further wonders when the voice of comparative anatomy tells him of their organization and consequent habits. None of these fall within the scope of my remarks; they are absent: we know that they existed contemporaneously with the deposition of these rocks and their included fossils: Stonesfield in this country, Pappenheim and Solenhofen in Germany assure us of this. Speaking with the caution which the subject demands, it may be asserted that the conditions of sea-bottom in our neighbourhood, though varying considerably during the time which was required for an accumulation of 400 feet in vertical thickness of solid rock, and the creation and ex-

* Read before the Cotteswold Naturalists' Club, August 8, 1848.